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(72) Inventor

Yoji Marutani

457-1 Kaiztukashi, Osaka-Fu

(72) Inventor:

Takashi Nakai

B43-6 3-8-1 Hirakata-Shi, Osaka-Fu

(72) Inventor

Seiji Hayano

Care of Mitsubishi Shoji Corporation 2-6-3 Marunouchi, Chiyodaku, Tokyo

(71) Applicant

Osaka-Fu

2 Otemaenomachi, Higashi-Ku, Osaka-Shi, Osaka-Fu

(71) Applicant

Mitsubishi Shoji Corporation

Mitsubishi Shoji Corporation 2-6-3 Marunouchi, Chiyodaku, Tokyo

(74) Agent

Eiji Saegusa (Benrishi) 2 others

Examiner:

Junko Uchida

(56) Reference Documents

KOKAI S60-247515 (JP, A) KOKAI S62-35966 (JP, A)

(57) Claims

1.

An optical fabrication method characterized by a photohardenable fluid medium contained in a container hardened by light with said fluid medium irradiated by light, the positions irradiated by said light moving relative to said container in the horizontal and vertical directions in correspondence to a target fabrication shape when forming a solid body into a desired shape wherein a reinforcing shape retention member is either attached to positions where there is a possibility that deformation may occur on the fabricated article or simultaneously hardened and formed extending from said positions on the fabricated article to other positions in order to prevent deformation of the solid portions during the formation process while forming a solid body after which said shape retention member is removed as necessary.

Detailed Description of the Invention

Industrial Field of the Invention

The present invention is related to an optical fabrication method that uses light and a photohardenable fluid medium to form a solid body into a desired shape.

Prior Art and Problems

Conventionally, the manufacture of models which correspond to a product shape required during the production of a mold or, the manufacture of models used for profiling control of machining processes or, the manufacture of models used for profiling discharge process electrodes were carried out by manual processes or by means of an NC machining process using an NC milling machine. However, the manual processes required a great deal of time and training and the NC machining process required complicated machining programs to be written taking into consideration replacement and wear due to cutting edge shape alterations of the blade. In addition, there was a problem wherein another finish process was required to remove the steps generated on the machining surface.

The inventors propose the optical fabrication methods described as follows as a means to solve these problems (KOKAI S60-24715, KOKAI S62-101408).

The first embodiments of these methods are embodiments wherein a solid body is formed into a desired shape by means of containing a photohardenable fluid medium in a container, determining a depth that allows the hardened portion to reach uninterrupted to the upper/lower surfaces of the fluid medium by means of light irradiation from above said container, selectively irradiating light from above said fluid medium through a light converging device (such as a convex lens) and then forming a hardened portion that reaches uninterrupted to the upper/lower surfaces of the fluid medium. Photohardenable fluid medium is further added onto said hardened portion in order to obtain a depth equivalent to the above-mentioned depth. Then, selective irradiation is carried out from said fluid medium forming a hardened portion continuously extending upward from the above-mentioned hardened portion. The above-mentioned solid body is formed by means of repeatedly adding photohardenable fluid medium, adding hardened medium and then forming a hardened portion.

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As shown in Fig. 9, adding the above-mentioned photohardenable fluid medium can be done by means of lowering base plate 52 supported on support column 51 within the fluid medium A and as shown in Fig. 10, can be done by means of raising fluid-tight box-shaped closed-end body 61 provided with a bottom wall 62 permeable to light within the fluid medium A. Hardened portion a shown in Fig. 9 and hardened portion b shown in Fig. 10 are both repeatedly hardened in steps and are members in the process of forming the above-mentioned solid body into a desired shape. A problem in this solid body formation process wherein various deformations would occur is described below.

Normally, photohardenable fluid medium A has shrinkage characteristics during the hardening and by means of repeatedly hardening in steps, differences in the amount of shrinkage between the hardened portions accumulates. Therefore, there was a problem in which differences in the amount of shrinkage on the end portion of tongue piece a' would cause deformation to occur when forming tongue piece a' on hardened portion a in the fluid medium adding method shown in Fig. 9.

In contrast, in the fluid medium adding method shown in Fig. 10, closed-end body 61 is raised one time higher than the depth the above-mentioned continuous hardened portion can obtain, the adhesion between bottom wall 62 and hardened portion b removed, and then closed-end body 61 is lowered and the distance between the lower surface of bottom wall 62 and the upper surface of hardened portion b is made a distance equivalent to the above-mentioned depth. However, there was a problem in which tongue piece b' moved together with closed-end body bottom wall 62 causing plastic deformation.

Furthermore, there was a problem wherein in order to obtain solid body 41 with the shape as shown in Fig. 11a in which each bottom surface of two truncated quadrilateral pyramids are joined, the shape would become solid body 42 as shown in Fig. 11b whose four side walls had a flexing deformation caused by differences in the amount of shrinkage when forming the solid body. Even further, when forming solid body 43 with a shape in which a square covering shown in Fig. 12a projects outward, the peripheral frame of covering portion 44' would become solid body 44 warped upward.

Other embodiments of the above-mentioned optical fabrication method include a fabrication method wherein a container that contains fluid medium A and a light guide member that guides light generated from a light source within fluid medium A of said container are moved relative to each other forming a solid body into a desired shape as well as another fabrication method wherein light generated from two light sources are converged into point shapes, each position where light energy converges intersects each other within fluid medium A, the intersecting portions are moved forming the above-mentioned solid body. These methods however, had a problem in which deformation occurred in like manner to Fig. 9, Fig.11b and Fig. 12b.

The object of the present invention is to provide an optical fabrication method that solves the above-mentioned problems and can prevent deformation form occurring when forming a hardened portion using light irradiation.

Methods to Solve the Problems

The object of the present invention mentioned above is achieved by means of an optical fabrication method characterized by a photohardenable fluid medium contained in a container hardened by light with this fluid medium irradiated by light. Then, the positions irradiated by this light move relative to the container in the horizontal and vertical directions in correspondence to a target

fabrication shape when forming a solid body into a desired shape. Furthermore, a reinforcing shape retention member is either attached to positions where there is a possibility that deformation may occur on the fabricated article or simultaneously hardened and formed extending from these positions on the fabricated article to other positions in order to prevent deformation of the solid portions during the formation process while forming a solid body after which the shape retention member is removed as necessary.

Various mediums which are hardened by means of light irradiation can be used for the photohardenable fluid medium. For example, denatured polyurethane methacrylate, oligo ester acrylate, urethane acrylate, epoxy acrylate, photosensitive polyimide and amino alkyd can be used.

A reforming material such as pigment, ceramic powder or metallic powder already mixed can also be used for the photohardenable fluid medium.

Various types of light can be used such as visible light or ultraviolet light which are suitable for the photohardenable medium that will be utilized. Although this light can be ordinary light, using laser light has the benefits of increasing the energy level thereby reducing the fabrication time and using favorable convergence characteristics, the fabrication precision can be improved.

Working Example

In the following a working example of the present invention will be described referring to the attached drawings.

Fig. 1 shows solid body 1 with an open-ended L shape seen from the side. This shape is the objective shape. Related to the fabrication method of this solid body 1, Fig. 3 shows a method (method shown in Fig. 9) that uses support column 51 and base plate 52 and Fig. 4 shows one mode when applying the present invention to a method (method shown in Fig. 10) that uses box-shaped closed-end body 61.

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At first, the method of the present invention shown in Fig. 3 will be described. Initially, as described above, base member 2 of solid body 1 forms on base plate 52 by lowering base plate 52 into photohardenable fluid medium A and by hardening and forming a portion based on selective irradiation through light converging device 6. After forming base member 2, side wall 3 forms extending upward from one edge of base member 2 and then upper wall 4 forms on side wall 3. Thin tongue piece 4' is formed corresponding to the lower edge of upper wall 4 in a process that gradually carries out the hardening and forming process. As shown in Fig. 9, thin tongue piece 4' deforms the easiest during the gradual hardening and forming process of solid body 1. Therefore, reinforcing shape retention member 5 is disposed extending across tongue piece 4' (which has a possibility of deforming) and the portion close to the other edge of base member 2 when forming the solid body into a related shape. After

simultaneously forming retention member 5 with the hardening and forming of side wall 3 and then forming side wall 3 and shape retention member 5, upper side portion 4 hardens and forms connected to the upper edges of side wall 3 and shape retention member 5. Because of this, tongue piece 4' is reinforced and supported by shape retention member 5 that extends to base member 2 while forming tongue piece 4' and since this prevents tongue piece 4' from deforming, upper side portion 4 can be formed without deformation. By means of removing shape retention member 5 using an appropriate cut from solid body 7 (see Fig. 2) formed in this manner, solid body 1 can be obtained with a desired shape without deformation.

Moreover, it is preferable to implement the following operation in practice when adding fluid medium A onto the hardened portion after forming the hardened portion based on one light irradiation. As shown in Fig. 7a, when base plate 52 is lowered onto the hardened portion to only a depth the hardened portion can reach uninterrupted and fluid medium A is allowed to flow onto the hardened portion, the distance the base plate 52 lowers is very small. Because of this, as shown in Fig. 7b, the surface tension of fluid medium A does not allow fluid medium A to flow onto the hardened portion which always results in an unreliable adding process and even further, makes it necessary to introduce fluid medium A onto the hardened portion manually requiring even more time. In contrast to this, as shown in Fig. 8, if base plate 52 is lowered lower than the above-mentioned depth and fluid medium A is allowed to flow onto the hardened portion and thereafter base plate 52 is lowered making the distance between the top surface of fluid medium A and the top surface of the hardened portion a distance equivalent to the above-mentioned depth, the adding process of fluid medium A can be done reliably without the need for manual introduction of fluid medium.

Next, the method of the present invention shown in Fig. 4 will be described. As shown in Fig. 10, the solid body is formed into a desired shape in this method by means of repeatedly forming the hardened portion based on raising box-shaped closed-end body 61 within fluid medium A and selective irradiation that passes through bottom wall 62. In like manner to Fig, 3, this method is also a method wherein solid body 1 is obtained without the above-mentioned deformation by means of forming base member 2 and hardening and forming side wall 3 while simultaneously hardening and forming shape retention member 5 extending across tongue piece 4' (which has a possibility of deforming) from base member 2 and then further forming upper wall 4 on side wall 3 and shape retention member 5 to obtain solid body 7 with a shape retention member attached after which shape retention member 5 is removed from solid body 7. According to this method as well, tongue piece 4' (which has a possibility of deforming) is reinforced and supported by shape retention member 5 thereby making it possible to obtain solid body 1 with a desired shape without deformation.

Next, forming solid 41 shown in Fig. 11a will be described. When acquiring the external shape of solid body 41 based on the optical fabrication method shown in Fig. 3 and Fig. 4, if the opposing side wall 31 continues to form simultaneously with reinforcing shape retention member 32 connected vertically while side wall 31 hardens and forms as shown in Fig. 5, side wall 31, which is easily flexed, will continue to be mutually supported by shape retention member 32. This makes it possible to prevent the above-mentioned flexing deformation and obtain solid body 33 with a shape retention member 32 attached having a stable external shape. Further, when obtaining solid body 43 with a shape in which a square covering shown in Fig. 12a projects outward, at first, during the hardening and forming of lower cylindrical body 35, reinforcing shape retention member 38 hardens and forms connecting to peripheral frame 37' (which has a possibility of deforming) of covering portion 37 extending upward from shape retention base member 36 that projects outward from the lower edge of lower cylindrical body 35 and from the peripheral frame of base member 36 as shown in Fig. 6a and Fig. 6b. Thereafter, covering portion 37 forms. Because of this, peripheral frame 37' (which has a possibility of deforming) is reinforced and supported on shape retention member 38 extending from shape retention base member 36 and deformation of peripheral frame 37' is prevented as shown in Fig. 12b. This makes it possible to obtain solid body 39 shown in Fig. 6a and Fig. 6b. Removing shape retention member 38 and shape retention base member 36 after obtaining solid body 39 makes it possible to obtain solid body 43 with a desired shape.

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Furthermore, as described above, the method of the present invention is characterized by a reinforcing shape retention member being either attached to positions where there is a possibility that deformation may occur or simultaneously being hardened and formed extending from these positions to other positions while forming a solid body with a desired shape. Insofar as these characteristics are provided, this method is applied to various fabrication methods based on light irradiation. Therefore, methods other than the fabrication method based on light irradiation stated in the above-mentioned working example can be applied to various methods. For example, a method that raises in slight increments the upper surface of a photohardenable fluid medium contained in a container and forms a solid body utilizing light irradiated from above. In this method, one portion of the side wall or bottom wall of the container is a transparent plate and the base surface for supporting the hardened surface is disposed facing towards the transparent plate. The solid body forms on the base surface based on light irradiated through the transparent plate while the base surface moves away from the transparent plate. Moreover, the light irradiation in these methods can utilize, for example, light irradiation using a semiconductor, light irradiation that intersects light generated from a plurality of light sources at one point, or irradiation of light that exhibits a circular light quantity distribution of the portion with a large light intensity positioned at

the cross section perpendicular to the optical axis. When using the above-mentioned light guide member, there is a benefit if the tip of the member is a hemispherical shape wherein light will be made to converge in a way that concentrates the light energy at a point allowing the light to irradiate. Even further, if light irradiation is used that causes the above-mentioned plurality of light sources to intersect, the light energy at positions where the light intersects can be made to increase in a non-linear manner making it possible to quickly form a solid body with a desired shape. If irradiation is carried out using light having a circular light quantity distribution as described above, a solid body with a comparatively wide band can be formed with dimensions of high accuracy on one scan of the irradiated light. This method efficiently forms a solid body with a desired shape.

Effects of the Invention

As made clear in the aforementioned description, according to the method of the present invention, positions where light energy concentrates and irradiates are moved relative to a photohardenable fluid medium forming a solid body into a desired shape. In the above-mentioned formation process, the solid body forms while a reinforcing shape retention member is either attached to positions where there is a possibility that deformation may occur on the fabricated article or simultaneously hardened and formed extending from said positions on the fabricated article to other positions. After the solid body forms, the shape retention member is removed as necessary. Therefore, it is possible to provide an optical fabrication method that can reliably prevent deformation from occurring during formation of the portion hardened by light irradiation based on said shape retention member.

Brief Explanation of the Drawings

Fig. 1 is a perspective view showing one example of a solid body formed based on the method of the present invention,

Fig. 2 is a perspective view showing one example of a solid body with a shape retention member attached,

Fig. 3 is an explanatory drawing schematically showing one working example of the present invention,

Fig. 4 is an explanatory drawing schematically showing another working example of the present invention,

Fig. 5 is a perspective view showing a solid body with a shape retention member attached obtained based on the method of the present invention,

Fig. 6a is a perspective view showing a solid body with a shape retention base member and a shape retention member attached obtained based on the method of the present invention,

Fig. 6b is a cross sectional view of Fig. 6a,

Fig. 7a and 7b are explanatory drawings showing a state in which conventional photohardenable fluid medium is added using a support column and a base plate,

Fig. 8 is an explanatory drawing showing a method that reliably allows the fluid medium to be added,

Fig. 9 is an explanatory drawing schematically showing one example of a conventional optical fabrication method,

Fig. 10 is an explanatory drawing schematically showing another example of a conventional optical fabrication method,

Fig. 11a is a perspective view showing a solid body obtained based on a conventional method,

Fig. 11b is a perspective view showing a solid body formed based on a conventional method,

Fig. 12a is a perspective view showing another solid body obtained based on a conventional method,

Fig. 12b is a longitudinal sectional side view showing a solid body formed based on a conventional method.

Explanation of Symbols

1 Solid body with desired shape

4' Upper piece lower portion (tongue piece)

5, 32, 38 Shape retention member

6 Light converging device

A Photohardenable fluid medium

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㉗発明者 丸谷 洋二 大阪府貝塚市水間457−1
㉗発明者 中井 孝 大阪府枚方市香里ケ丘3−8−1 B43−6
㉗発明者 早野 誠治 東京都千代田区丸の内2丁目6番3号 三菱商事株式会社内
㉛出願人 大阪府 大阪府大阪市東区大手前之町2番地
㉛出願人 三菱商事株式会社 東京都千代田区丸の内2丁目6番3号
㉔代理人 弁理士 三枝 英二 外2名
審査官 内田 淳子

OSAKA-FU & MITSUBISHI CORPORATION

㊺参考文献 特開 昭60−247515(JP, A)　特開 昭62−35966(JP, A)

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㊼特許請求の範囲

1 光により硬化する光硬化性流動物質を容器内に収容し、該流動物質中に光照射を行ないつつ、該光照射箇所を前記容器に対し水平及び垂直方向に造形対象の形状に応じて相対移動させ、所望形状の固体を形成するにあたり、該形成過程における硬化部分の変形を防止するために、造形物における変形発生のおそれある箇所に付着され、又は造形物における該箇所と他の箇所とにわたつて延びる補強用の形状保持部を同時に硬化形成しつつ前記固体形成を行ない、該形成後に前記形状保持部を必要に応じて除去することを特徴とする光学的造形法。

発明の詳細な説明

産業上の利用分野

本発明は、光及び光硬化性流動物質を用いて所望形状の固体を形成する光学的造形法に関する。

従来の技術及びその問題点

従来、鋳型製作時に必要とされる製品形状に対応する模型、或いは切削加工の倣い制御用又は形彫放電加工電極用の模型の製作は、手加工により、或いはNCフライス盤等を用いたNC切削加工により行なわれていた。しかしながら、手加工による場合は多くの手間と熟練とを要するという問題が存し、NC切削加工による場合は、刃物の刃先形状変更のための交換や摩耗等を考慮した複雑な工作プログラムを作る必要があると共に、加工面に生じた段を除くために更に仕上げ加工を必要とする場合があるという問題が存していた。

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このような問題を解決するものとして本発明者は、以下に示す光学的造形法を提案している(特開昭60−247515号、特開昭62−101408号)。

該方法の1実施態様は、光硬化性流動物質を容器内に収容して該容器の上方からの光照射により流動物質上下面に及ぶ連続した硬化部分が得られる深さとし、該流動物質の上方から凸レンズ等の光収束器を介して選択的に光照射を行ない、該流動物質上下面に及ぶ硬化部分を形成し、更に該硬化部分上に前記深さに相当する深さをなすよう、光硬化性流動物質を付加し、該流動物質から選択的光照射を行なつて前記硬化部分から連続して上方へ延びた硬化部分を形成し、これら光硬化性流

動物質の付加及び硬化物質の付加及び硬化部分の形成を繰り返して所望形状の固体を形成するものである。

前記光硬化性流動物質の付加は、第９図に示すように、支持棒５１に支持されたベースプレート５２を該流動物質Ａ中で下降させることにより行なうことができ、第１０図に示すように、光透過性を有する底壁６２を備える液密な箱状有底体６１を流動物質Ａ中で上昇させることにより行なうこともできる。第９図に示す硬化部分ａ及び第１０図に示す硬化部分ｂは、それぞれ段階的硬化が繰り返され、前記所望形状の固体を形成する途上のものである。この固体形成過程においては、以下に述べる種々の変形の発生が問題となる。

一般に、光硬化性流動物質Ａは、硬化時の収縮性を有しており、段階的硬化が繰り返されることにより、硬化部分間の収縮量の差が蓄積する。従つて、第９図に示した流動物質付加方法においては、硬化部分ａに舌片ａ′を形成する際に、該舌片ａ′端部に収縮量相違による変形が発生するという問題があつた。

一方、第１０図に示した流動物質付加方法においては、有底体６１を上記連続した硬化部分が得られる深さよりも一旦上昇させて底壁６２と硬化部分ｂとの付着を剥離し、その後有底体６１を下降させて底壁６２下面と硬化部分ｂ上面との距離を、前記深さに相当する距離とするのであるが、舌片ｂ′が上記剥離の際に有底体底壁６２に伴われて塑性変形を起こすという問題があつた。

更に、２つの截頭四角錐の各底面が合わせられた第１１ａ図に示すような形状の固体４１を得るために、固体形成を行なつた場合には、第１１ｂ図に示すように、収縮量相違により四周側壁が湾曲変形した固体４２になり、また、第１２ａ図に示す方形屋根が張り出した形状の固体４３の形成を行なつた場合には、第１２ｂ図に示すように屋根部４４′の周縁が上方へ反つた固体４４になるという問題があつた。

上記光学的造形法の他の実施態様として流動物質Ａを収容した容器と、光源装置から発せられる光を該容器の流動物質Ａの中に導く導光体とを相対的に移動させ、所望形状の固体を形成する造形法、及び２つの光源から発せられた光をそれぞれ点状に収束させ、それぞれの光エネルギ集中照射

箇所を流動物質Ａ中で相互に交差させ、該交差部を移動させて上記固体を形成する造形法があるが、これらの場合にも、第９図、第１１ｂ図及び第１２ｂ図に示したと同様の変形が発生するという問題があつた。

本発明は、上記問題点を解決し、光照射による硬化部分形成時に、変形の発生を防止し得る光学的造形法を提供することを目的とする。

問題点を解決するための手段

本発明の上記目的は、光により硬化光硬化性流動物質を容器内に収容し、該流動物質中に光照射を行ないつつ、該光照射箇所を前記容器に対し水平及び垂直方向に造形対象の形状に応じて相対移動させ、所望形状の固体を形成するにあたり、該形成過程における硬化部分の変形を防止するために、造形物における変形発生のおそれある箇所に付着され、又は、造型物における該箇所と他の箇所とにわたつて延びる補強用の形状保持部を同時に硬化形成しつつ前記固体形成を行ない、該形成後に前記形状保持部を必要に応じて除去することを特徴とする光学的造形法により達成される。

前記光硬化性流動物質としては、光照射により硬化する種々の物質を用いることができ、例えば変性ポリウレタンメタクリレート、オリゴエステルアクリレート、ウレタンアクリレート、エポキシアクリレート、感光性ポリイミド、アミノアルキドを挙げることができる。

該光硬化性流動物質に、予め顔料、セラミックス粉、金属粉等の改質用材料を混入したものを使用してもよい。

前記光としては、使用する光硬化性物質に応じ、可視光、紫外光等種々の光を用いることができる。該光は通常の光としてもよいが、レーザ光とすることにより、エネルギーレベルを高めて造形時間を短縮し、良好な集光性を利用して造形精度を向上させ得るという利点を得ることができる。

実施例

以下に、本発明の実施例を、添付図面を参照しつつ説明する。

第１図は、目的とする側面視コ字形状の固体１を示す。この固体１の造形法に関し、第３図は、支持棒５１及びベースプレート５２を用いた方法（第９図に示したもの）、第４図は、箱状有底体６

1を用いた方法（第10図に示したもの）に、各々本発明を適用する場合の1態様を示す。

最初に、第3図に示す本発明方法を説明する。先ず、上述の如き光硬化性流動物質A中でのベースプレート52の下降及び光収束器6を介する選択的光照射に基づく硬化部分形成を繰り返し、ベースプレート52上に固体1の基部2を形成する。基部2を形成した後、該基部2の一端から上方へ延びる側壁部3を形成し、その後に該側壁部3上に上壁部4を形成するのであるが、段階的硬化形成を行なう過程で上壁部4の下端部に相当する薄い舌片4′が形成される。該舌片4′は、第9図に示したように、固体1の段階的硬化形成途上において、最も変形し易い。よつて、かかる形状の固体形成の場合は、該変形発生のおそれある舌片4′と基部2の他端近傍部とにわたつて延びる補強用の形状保持部5を設けることとし、該保持部5を側壁部3の硬化形成と同時に形成し、該側壁部3及び形状保持部5を形成した後、これら上端に連続する上辺部4を硬化形成する。従つて、舌片4′の形成時には、基部2か延びる形状保持部5が舌片4′を補強支持し、該舌片4′の変形発生を防止するので変形のない上辺部4とすることができる。このようにして形成した固体7（第2図参照）から形状保持部5を切断等適宜の方法で除去することにより、変形のない所望形状の固体1を得ることができる。

なお、一旦光照射に基づく硬化部分形成を行なつた後、該硬化部分上に流動物質Aを付加する場合、実際には次の操作を行なうのが望ましい。第7図aに示すように、硬化部分上に連続した硬化部分が得られる深さだけベースプレート52を下降させて該硬化部分上に流動物質Aを流入させる場合、該ベースプレート52の下降距離が極めて僅かであることから、第7図bに示すように、流動物質Aの表面張力により、硬化部分上に該流動物質Aが流入しないことがあり、常に上記付加の確実性に欠け、更に人手による硬化部分上への流動物質Aの導入を要し、手間を要する。これに対し、第8図に示すように、ベースプレート52を上記深さよりも下降させて硬化部分上に流動物質Aを流入させ、そののちベースプレート52を上昇させて流動物質A上面と硬化部分上面との距離を前記深さに相当する距離とすれば、流動物質Aの付加を確実に行なうことができ、人手による流動物質の導入を要しない。

つぎに第4図に示す、本発明方法を説明する。該方法は、第10図に示した如く、箱状有底体61の流動物質A中での上昇、及び底壁62を透過する選択的光照射に基づく硬化部分形成を繰り返して所望形状の固体を形成するものである。該方法も、第3図に述べたと同様に、基部2を形成し、そののち側辺部3の硬化形成を行ないつつ、同時に基部2から変形のおそれある舌片4′にわたつて延びる形状保持部5を硬化形成し、更に該側辺部3及び形状保持部5上に上辺部4を形成して第2図に示す形状保持部付き固体7を得、該固体7から形状保持部5を除去して、上述の変形のない所望形状固体1を得るものである。この方法によつても、変形発生のおそれある舌片4′は、形状保持部5に補強支持され、よつて変形のない所望形状の固体1を得ることができる。

次に、第11a図に示した固体41を形成する場合について説明すると、第3図又は第4図に示した光学的造形法に基づき該固体41の外形を得るにあたり、第5図に示すように、側壁31を硬化形成しつつ、対向する側壁31どうしを垂直に連結する補強用形状保持部32を同時に形成すれば、湾曲変形し易い側壁31どうしが形状保持部32を介して互いに支持し合い、これにより前記湾曲変形の発生が防止されて、正確な外形を有する形状保持部32付き固体33を得ることができる。また、第12a図に示した方形屋根張り出し形状の固体43を得る場合には、第6a図及び第6b図に示すように、先ず下部筒体35の硬化形成の際に、該下部筒体35下端部から外方へ張り出す形状保持基部36及び該基部36周縁から上方へ延びて屋根部37の変形発生おそれある周縁部37′に連続する補強用形状保持部38を硬化形成し、そののち屋根部37を形成する。これにより、変形発生のおそれある周縁部37′が形状保持基部36から延びる形状保持部38に補強保持され、第12b図に示したような周縁部37′の変形発生が防止され、第6a図及び第6b図に示す固体39とすることができる。該固体39を得たのち、該固体39から形状保持部38及び形状保持基部36を除去することにより、所望形状の固体43を得ることができる。

なお、本発明方法は、上述のように、変形発生のおそれある箇所に付着され、又は該箇所と他の箇所とにわたつて延びる補強用の形状保持部を同時に硬化形成しつつ所望形状の固体形成を行うことを特徴とするものであり、この特徴を備える限りにおいて、光照射に基づく種々の造形法に適用されるものである。従つて、上記実施例に述べた光照射に基づく造形法の外、例えば容器内の光硬化性流動物質の上面を僅かずつ上昇させ上方からの光照射により固体を形成する方法、容器の側壁又は底壁の一部を透明板とし、該透明板に向けて硬化部分支持用の基盤面を配置し、該基盤面を透明板から遠ざけつつ該透明板を介する光照射に基づき基盤面に固体を形成する方法などに適用され得る。また、これら方法における光照射は、例えば導光体を用いた光照射、複数の光源から発せられる光を一点に交差させる光照射、光軸に垂直な断面における光強度の大きい部分が環状の光量分布を呈する光の照射などを採用できる。上記導光体を用いる場合、該導光体の先端部を半球状のものとすれば、光エネルギが点状に集中するように光を収束させて照射を行い得るという利点がある。また、上記複数光を交差させる光照射を採用すれば、該光交差箇所において光エネルギを非線形的に増加させることができ、所望形状の固体を速やかに形成することができる。上記環状の光量分布を有する光の照射を行えば、該光照射の1度の走査で比較的太い帯状固体を高い寸法精度で形成することができ、所望形状の固体形成を効率良いものとする。

発明の効果

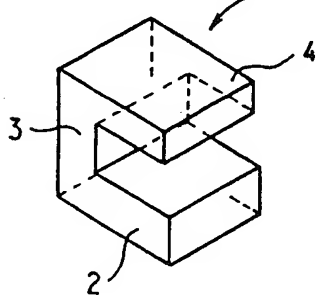
以上から明らかなように、本発明方法によれば、光硬化性流動物質に対し、光エネルギ集中照射箇所を相対移動させ、所望形状の固体を形成するにあたり、該形成過程において、造型物における変形発生のおそれある箇所に付着され、または、造型物における該箇所と他の箇所とにわたつて延びる補強用の形状保持部を同時に硬化形成しつつ前記固体形成を行ない、該形成後に前記形状保持部を必要に応じて除去するので、該形状保持部に基づき、光照射による硬化部分形成時特有の変形発生を確実に防止できる光学的造形法を提供することができる。

図面の簡単な説明

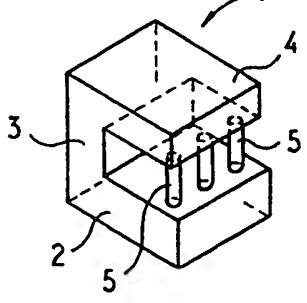
第1図は本発明方法に基づき形成する固体の1例を示す斜視図、第2図は形状保持部付き固体の1例を示す斜視図、第3図は本発明方法の1実施例を概略的に示す説明図、第4図は本発明方法の他の実施例を概略的に示す説明図、第5図は本発明方法に基づき得られる形状保持部付き固体を示す斜視図、第6a図は本発明方法に基づき得られる形状保持基部及び形状保持部付き固体を示す斜視図、第6b図はその縦断正面図、第7図a，bは支持棒及びベースプレートを用いた従来の光硬化性流動物質の付加状態を示す説明図、第8図は該流動物質を確実に付加し得る方法を示す説明図、第9図は従来の光学的造形法の1例を概略的に示す説明図、第10図は従来の光学的造形法の他の例を概略的に示す説明図、第11a図は従来方法に基づき得ようとする固体を示す斜視図、第11b図は従来方法に基づき形成された固体を示す斜視図、第12a図は従来方法に基づき得ようとする他の固体を示す斜視図、第12b図は従来方法に基づき形成された固体を示す縦断側面図である。

1……所望形状の固体、4′……上片下部（舌片）、5，32，38……形状保持部、6……光収束器、A……光硬化性流動物質。

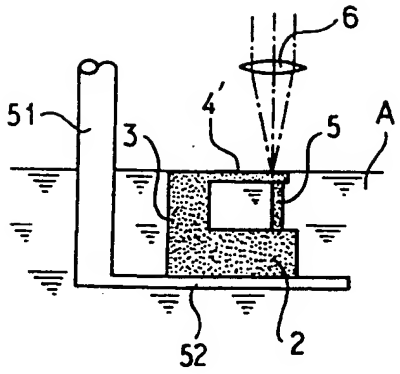
第1図



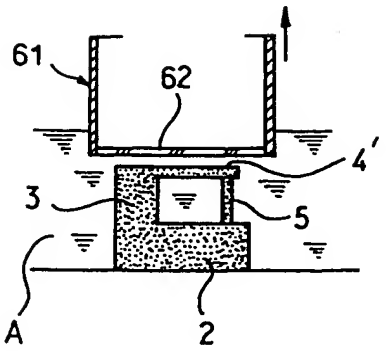
第2図



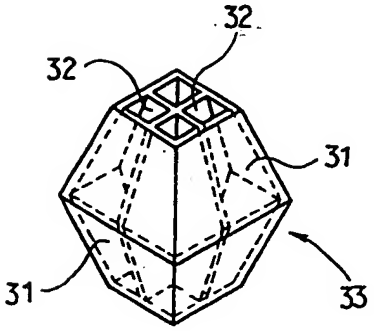
第3図



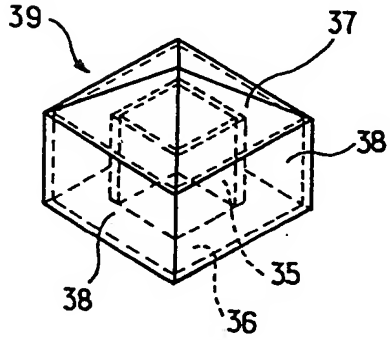
第4図



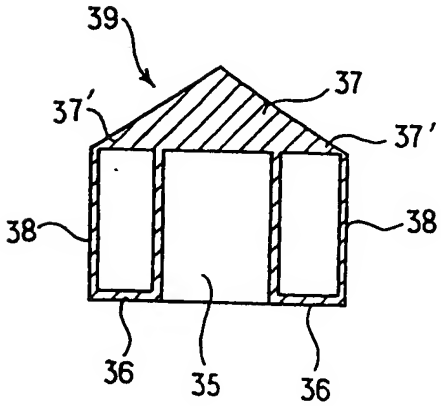
第5図



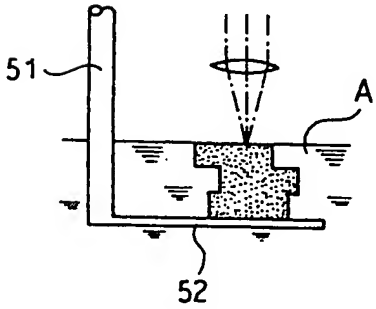
第6図 a



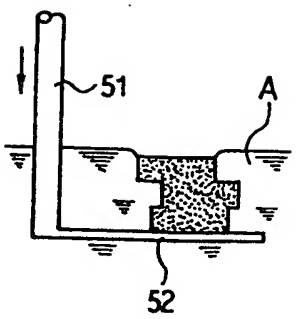
第6図 b



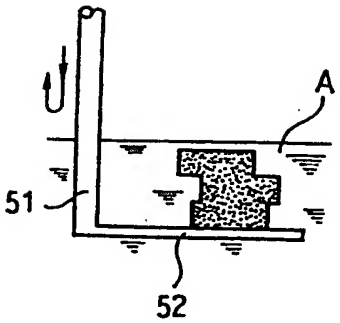
第7図 a



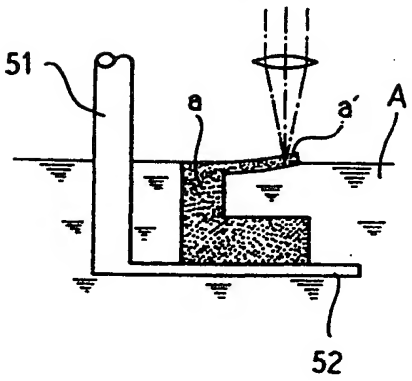
第7図 b



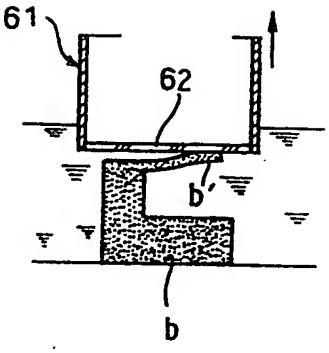
第8図



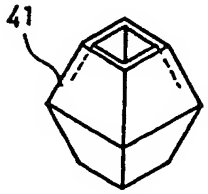
第9図



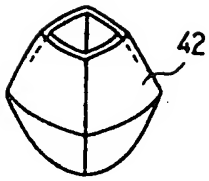
第10図



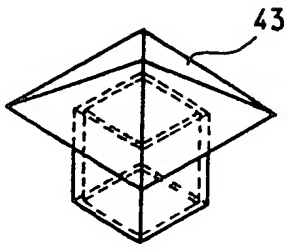
第11図 a



第11図 b



第12図 a



第12図 b